HAMILTONIAN THEORY OF THE FRACTIONAL QUANTUM HALL EFFECTS

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The quantum Hall effect occurs when a two-dimensional electron gas is subjected to a very high magnetic field. In these fields the interaction between electrons becomes all-important, and they reorganize themselves into exotic states whose fundamental excitations, their "particles" have fractional charge, dubbed Composite Fermions.

While many of the qualitative and quantitative features of this effect have been understood for some time, work carried out by Murthy and Shankar has constructed a theory in which one is able to understand the structure of the Composite Fermion in detail, and to calculate virtually any physical quantity by means of simple approximations.

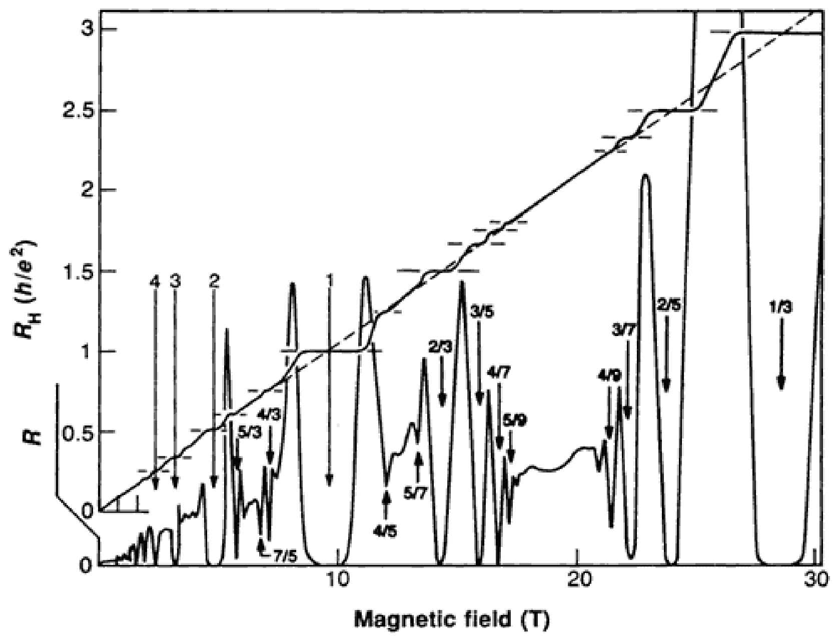

Fig. 1: Dissipative (lower trace) and Hall (upper trace) resistances of a quantum Hall system. Plateaus in the Hall resistance are accurately quantized to better than one part in ten billion, allowing the effect to be used as a fundamental standard of resistance.

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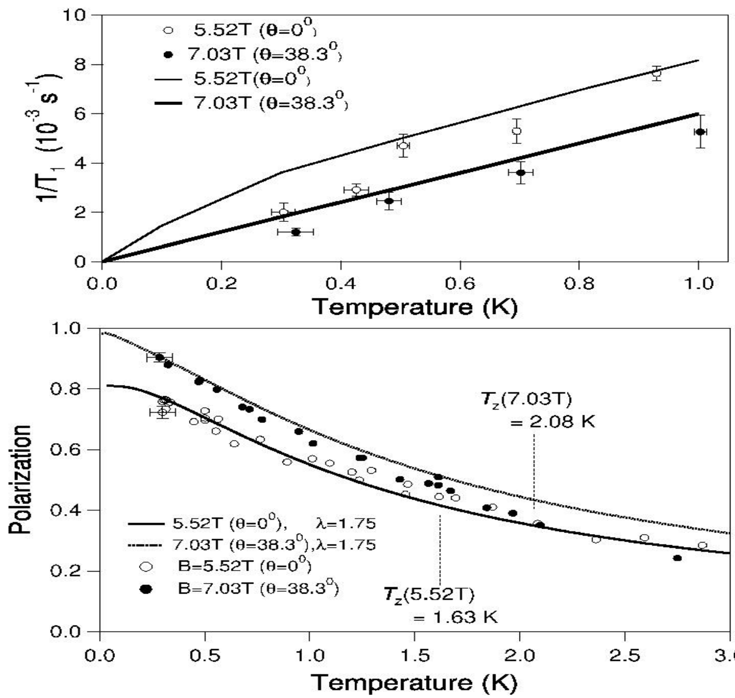
The key turns out to be to introduce additional particles called pseudovortices to represent correlations between the electrons. While the theory in terms of electrons alone is complicated, the theory with pseudovortices included is simple and naturally shows the emergence of the Composite Fermion, together with its fractional charge.



Theoretical prediction (solid lines) compared to the experiments for two values of magnetic field (open and filled symbols). The data are from Dementyev et al (Physical Review Letters, 83, 5074 (1999)).

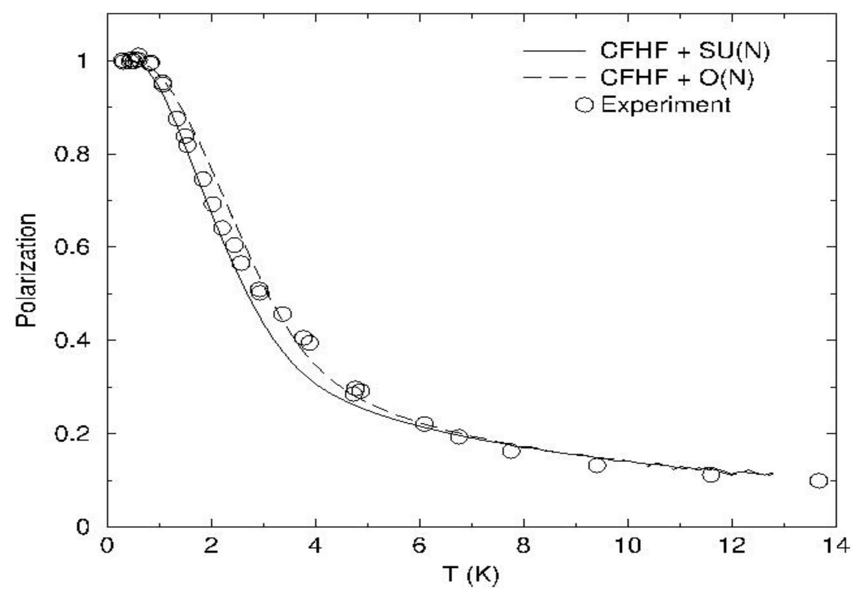


Fig. 1: Two sligltly different theoretical predictions for the spin polarization of the 1/3 FQHE state (solid and dashed lines) compared to the data of Khandelwal et al (Physical Review Letters, 81, 673 (1998)).

Collaborators on this project include H. A. Fertig and R. Narevich.